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THE TOXICITY OF THE NATURAL BITTER SUBSTANCES, QUASSIN, TENULIN, HELENALIN, AND PICROTOXIN, AND SOME OF THEIR DERIVATIVES TO CERTAIN INSECTS

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A comparison was made of the insecticidal action of pyrethrum extract or nicotine and the natural bitter substances, quassin (a natural mixture of quassin and neoquassin), picrotoxin, helenalin, tenulin, and certain of their derivatives, namely, isoquassin, isotenulin, and bromopicrotoxinin. The information presented is of interest, for, while the chemical nature of these materials is unknown, they have enough chemical similarity to warrant the assumption that they have some common structural characteristics. The insecticidal properties of the quassins are of special interest, since all previous reports as to the effectiveness of quassia wood in this respect were based on results obtained with extracts of unknown composition. The crystalline quassins, however, are presumed to be the physiologically active constituents of the wood.

Quassia wood extracts have been found effective against certain aphids and not effective against other species (2).^{1/} Also these extracts have been found effective against certain sawflies but not other insects (3 and 4). The entomological publications on quassia up to 1937 have been reviewed (1).

The insects used in the tests reported in this circular were the green peach aphid, the Mexican bean beetle, the American cockroach, and the housefly. The procedures used in testing the materials are given in connection with the various experiments.

Insecticidal Tests

Green peach aphid.—Nymphs and adults of the green peach aphid (*Myzus persicae* (Sulz.)) feeding on turnip leaves were sprayed in the laboratory in a spray tower 2 feet in diameter and 4 feet high. Preliminary tests had shown that when approximately 50 ml. of spray liquid were discharged in the

1/ The numbers in parenthesis refer to the literature cited (p. 5).

spray tower one surface of the turnip leaves appeared uniformly covered with large droplets of spray that did not coalesce and drain to the edges of the leaves. As most of the aphids were on the lower surface of the leaves, the few that were found on the upper surface were removed, and the spray was applied only to the lower surface. This procedure was therefore used. The exact quantities used in each series of tests are given in table 1. The sprays were prepared by adding 20 ml. of the acetone solution of the material to 80 ml. of water that contained 0.1 percent of gum arabic.

As shown in table 1, so far as the green peach aphid is concerned the materials under consideration have practically no aphidicidal action.

Table 1.--Mortality of green peach aphids sprayed with aqueous solutions or suspensions. Nicotine was used as the standard of comparison.

Series No.	Material		Quantity applied	Number of tests	Number of aphids used	Mortality in 24 hours
	Name	Concentration of solution	Percent	ml.		Percent
1	Nicotine	0.1	50	5	260	51
2	Isoquassassin	1.0	49	2	74	0
3	Quassassin	1.0	49	5	515	4
4	Isotenulin	1.0	49	3	222	1
5	Tenulin	1.0	49	3	159	0.6
6	Helenalin	1.0	49	3	237	1
7	Picrotoxin	1.0	48	3	192	0.6
8	Bromopicrotoxinin	1.0	51	3	240	0
9	Check (acetone 20%, gum arabic 0.1%)	--	50	5	480	0.2
10	Check (water)	--	52	1	57	0

Mexican bean beetle.--Five-percent acetone solutions of the various substances were applied by means of a micropipette to the ventral surface of adults and larvae of the Mexican bean beetle (*Epilachna varivestis* Muls.).^{2/} Five lambda (0.005 milliliter) were applied to each adult and fourth instar and 2.5 lambda to each second instar. The number of dead insects was determined after 3 days. Each mortality figure is the average of 3 tests of 10 insects each. The second instars gave a better comparison

2/ The writers express thanks to G. L. Phillips for assisting in making these tests.

of the toxicity of the materials used than the adults or fourth instars (table 2), but these larvae were not sufficiently resistant to nicotine for the data on it to be directly compared with the data on the other materials. All the tests indicated that the experimental materials were much less toxic than nicotine when used at the same dosage.

Table 2.--Results obtained by applying 5-percent solutions of test materials to Mexican bean beetle larvae and adults. Nicotine was used as the standard.

Series No.	Material	Mortality in 3 days		
		Adults	Fourth-instar larvae	Second-instar larvae
		Percent	Percent	Percent
1	Nicotine	67	77	100
2	Picrotoxin	9	13	80
3	Quassassin	9	13	80
4	Isoquassassin	18	13	63
5	Helenalin	34	17	67
6	Tenulin	9	3	50
7	Isotenulin	3	0	57
8	Check (acetone)	0	0	13

Cockroaches.--Adult American cockroaches (*Periplaneta americana* (L.)) were treated individually at the rate of 5 lambda of 5-percent acetone solution of the material per gram of insect. The solution was applied by means of a micropipette to the dorsal surface of the integument of the thorax and abdomen. After treatment the roaches were placed in cages with food and water, and the knockdown and mortality were observed for 4 days. The results given in table 3 are the average of three tests of 5 female roaches in each test.

As shown in table 3, quassassin and tenulin caused neither knockdown nor mortality. Picrotoxin showed some toxicity to the roaches and caused the highest mortality of the materials of unknown toxicity, but it was considerably lower than that for pyrethrins used at a greater dilution. The male roaches were less resistant than the females.

Table 3.--Knockdown and mortality of American cockroaches treated individually. Pyrethrum extract was used as the standard.

Series No.	Material in acetone solution		Knockdown in 1 day		Mortality in 4 days	
	Name	Concentration of solution	Male	Female	Male	Female
	Percent	Percent	Percent	Percent	Percent	Percent
1	Pyrethrins	0.1	93	60	93	66
2	Tenulin	5.0	0	0	0	0
3	Isotenulin	2.5	7	0	7	7
4	Helenalin	5.0	0	0	7	0
5	Picrotoxin	5.0	14	7	40	7
6	Quassin	5.0	0	0	0	0

Houseflies.--Reared adult houseflies^{3/} (*Musca domestica* L.) that were 3 to 5 days old were treated individually with 2 lambda of acetone solutions of the materials listed in table 4. The liquids were applied to the ventral surface of the abdomen by means of a micropipette after the flies were rendered motionless by chilling them for about 3 1/2 minutes. The untreated check flies (series 10, table 4) were also chilled. After treatment the flies were placed in 6-inch petri dishes with screen covers and supplied with sugar and water. The dead flies were counted for 4 days and are recorded (table 4) under percent of mortality. The figures are the average of 5 tests of 10 flies each.

The results show that none of the materials under consideration showed appreciable toxicity to the flies under the conditions of the experiment.

3/ The authors thank W. N. Sullivan and J. H. Fales for supplying the houseflies used in these experiments.

Table 4.--Results obtained by treating adult houseflies individually with 2 lambda of acetone solutions of the materials indicated. Pyrethrum extract was used as the standard of comparison.

Series No.	Material		Mortality after 4 days
	Name	Concentration of solution	
	Percent	Percent	
1*	Pyrethrins	0.2	40
2	Pyrethrins	0.4	77
3	Quassassin	5.0	0
4	Isoquassassin	5.0	4
5	Tenulin	5.0	2
6	Isotenulin	2.5	2
7	Helenaline	5.0	10
8	Picrotoxin	5.0	6
9	Check (acetone)	--	2
10	Check (untreated)	--	2

*These pyrethrin solutions were made by dissolving a pyrethrum oleoresin, which contained 12.7 percent of pyrethrin I and 12.6 percent of pyrethrin II, in acetone.

Summary

Laboratory insecticidal tests of quassassin, isoquassassin, picrotoxin, helenalin, tenulin, and isotenulin on the green peach aphid on turnip, the housefly, and the Mexican bean beetle showed that these materials had little if any toxicity to these insects. Secnd instars of the Mexican bean beetle were susceptible to these materials, but adults and fourth instars were much more resistant. These same materials, with the exception of isoquassassin, which was not tested, were relatively nontoxic to the American cockroach. Bromopicrotoxinin was nontoxic to the green peach aphid. While the insects used in these tests were resistant to quassassin, a survey of the literature shows that quassia wood extract is effective against certain sawflies and aphids which were not included in these tests.

Literature Cited

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